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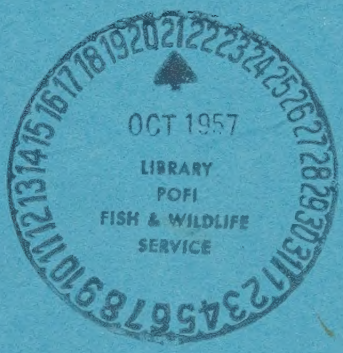
ISSUE TWENTY
AUGUST-1957

THE CANADIAN FISH CULTURIST



Published at Ottawa by
The Department of Fisheries of Canada

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Minister of Fisheries

Comparative Survival and Growth of Tagged and Untagged Brook Trout

by

M. W. Smith

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Jaw-tags have been used in a study of the movements and populations of the eastern brook trout (*Salvelinus fontinalis*) in Prince Edward Island streams (Smith, 1951; Smith and Saunders, 1956). However, possible effects of these tags upon the well-being of the trout have not been assessed. To obtain information of this sort, tagged and untagged brook trout were held in two Prince Edward Island ponds, one (Simpson's) of 2.3 and the other (Stevenson's) of 3.0 acres in area.

Procedure

On September 23-24, 1954, equal numbers (367) of tagged and untagged trout, age 1, were planted in Stevenson's Pond. The survival and growth of these trout were determined 248 days later on May 30, 1955, by draining the pond. On June 3-4, 1955, 333 tagged and 330 untagged trout, age 1, were also planted in Simpson's Pond. Assessment of survival and growth was made 108 days later on September 20-22, 1955. The ponds were drained prior to the planting, and any trout removed.

The ponds have been formed on small spring-fed streams and are readily drained to the original stream bed. The trout were efficiently recaptured on draining by trapping at the dams as the water was lowered (the majority of the fish were accounted for in this way) and by liming the stream to drive down any remaining individuals. Self-cleaning screens at the dams, and barriers at the heads of the ponds prevented escapement of the trout.

The tags employed were of the strap variety, 3.5 x 0.3 cm. in dimensions (number 2, Salt Lake Stamp Company). The tags were serially numbered. They were applied in a circular form around the mandible of the fish (Fig. 1). The ends of the tags overlapped and were pressed together, but not clinched. Rupp (Anon. 1952) and Horrocks (Anon. 1956) have devised pliers for applying this strap jaw-tag. To distinguish the trout in the event that tags were lost, the tagged individuals had the adipose and right ventral, and the untagged, the adipose and left ventral, fins removed. The fork length of each trout was measured on planting and on recovery. Except in June, 1955, at Simpson's Pond, when they were weighed in groups of ten, the weight of each trout was determined to the nearest quarter-of-an-ounce. The mean weights have been converted to grams in Table II.

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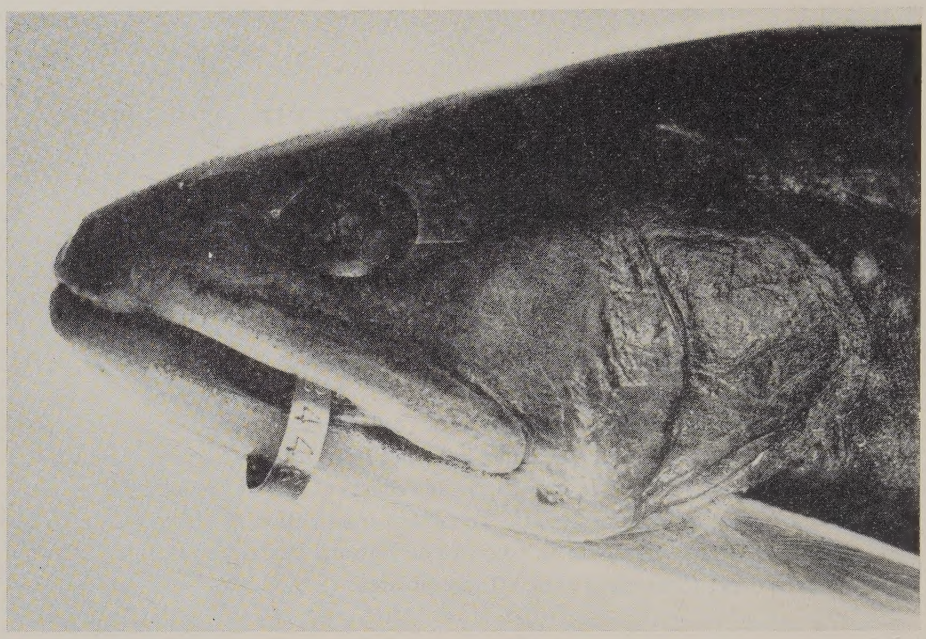

Figure 1.—Head of 24-centimetre brook trout showing attachment of circular jaw-tag.

Survival

The numbers of tagged and untagged trout that were planted and the numbers recovered on draining the ponds are given in Table I. Differences in the percentage recovery between the tagged and untagged trout were small. A somewhat better recovery of tagged trout was found when the fish were held over winter in Stevenson's Pond. The reverse situation was experienced for the summer period in Simpson's Pond.

In tagging, the trout may suffer ill-effects not only from carrying the tag, but also from the necessary handling in capture and application of the tag. In our tests the untagged trout were marked by fin-clipping. They were handled about as much as those that were tagged. The carrying of the tag was the principal difference experienced by the two groups. It may be concluded from the data that the carrying of the tag did not affect the survival of the trout adversely.

Growth

The length and weight of the tagged and untagged trout when planted and on recapture are given in Table II. In both Stevenson's and Simpson's ponds the untagged trout gained more in length and weight, but this gain was the greater in the former pond. (The difference in mean length on recovery between the tagged and untagged trout from Stevenson's Pond is significant at the 1 per cent level.) The apparent effect of the tag upon growth was most adverse when the trout were held longer and over a winter period.

In either pond both groups of trout were subjected to the same environmental conditions and had a common food supply. Almost the only difference in treatment of the two groups was the tagging. With other factors comparable, growth may be considered almost entirely as a function of feeding. Our results suggest that the jaw-tagging interfered to a moderate degree with the ability of the trout to feed and resulted in the differences in growth between the tagged and untagged fish. Rounsefell and Everhart (1953) point out that the jaw-tag "has been criticized on the grounds that there is evidence that fish so tagged do not feed properly".

The relative heaviness of the trout, as expressed by the condition factor K and determined from the relationship, weight $\times$ 100 $=$ K (length)^3, was calculated from the mean length and weight of the trout (Table III). The untagged trout on recovery from Stevenson's Pond had the higher condition factor. The result is in keeping with that reported by Schuck (1942) upon the effects of jaw-tagging brown trout in Crystal Creek, New York. He found that tagged wild brown trout were significantly lighter for their length than untagged individuals after being at large for one and two years. However, the results from Simpson's Pond, in which the trout were held only over a summer period, are not in agreement. Actually the untagged trout were lighter in weight for their length. The differences in results suggest that the longer the tags are carried, more adverse are the effects.

It is pertinent to note that the tagged trout recovered from Stevenson's and Simpson's ponds exhibited no pathological condition arising from the tags.

Loss of Tags

It was possible to determine whether tags were lost since the tagged trout also had the adipose and right ventral fins removed. It was found that the loss of tags from trout held over winter in Stevenson's Pond was considerable. Twenty-eight per cent of the trout that had been tagged and were recaptured (195) lost the tags during the 248 days in the pond. In contrast, no tags had been lost by the tagged trout (233) recovered from Simpson's Pond after being held a 108-day summer period. The time interval at large may have been a factor in the differences in loss of tags. The trout were held in Stevenson's Pond about twice the length of time that those were retained in Simpson's.

The size of fish may also have been an important factor in the loss of tags. When recaptured in Stevenson's and Simpson's ponds the mean lengths of the tagged trout were 26.2 and 21.4 cm., respectively. At Stevenson's Pond the recaptured tagged trout still retaining the tags was 26.0 cm., while those that had lost them averaged 26.5 cm. The difference in mean length was small, but suggested that the larger individuals were more prone to lose tags. The tags were not clinched when applied. The ends of the tags may spring apart as the fish become larger and make loss of the tags easier.

Some evidence was previously obtained from trout held in rearing ponds at the Saint John, N.B., fish hatchery of the federal Department of Fisheries, that the tag employed in our studies at Stevenson's and Simpson's ponds was too small for fish approximately 30 cm. in length. Of 98 trout tagged on July 16, 1947, at a mean length of 21.7 cm., 17 per cent lost the tags by December 3 of the same year. However,

83 per cent of the tags were lost by the following April. At that time the trout still retaining the tags averaged 29.9 cm. in length. The tags that held firm were becoming embedded in the mandible. Shetter (1936) found that there was a heavy loss of tags which were not sufficiently large to accommodate increase in size of the mandible.

It was indicated by observations at Stevenson's Pond that fin-clipping should be combined with tagging to evaluate properly the effects of the tags on survival and growth. Although certain of the trout that had lost tags could be identified from wound scars which resulted from applying the tags, it was noted that such wounds apparently may heal thoroughly. Previously tagged trout could be easily overlooked.

Summary

Jaw-tags on brook trout had no demonstrable effect upon survival in cool waters and when held for periods of less than one year. However, growth was retarded, presumably through interference with feeding. Growth was more retarded in ponds when the trout were held for 248 days over a winter period, than when retained 108 days in the summer season. A growth correction factor is indicated for tagged trout, but the correction will vary in magnitude with length of time and conditions under which the trout are held. Trout which have lost tags are not always recognizable from wounds caused by tagging. Fin-clipping provides identification of such fish.

Acknowledgments

The assistance in the field of J. W. Saunders, C. R. Hayes, and Cyril Williams is gratefully acknowledged. This paper is published with permission of the Fisheries Research Board of Canada.

Table I

Survival of tagged and untagged trout in ponds

I. Stevenson's Pond

——	Planted Sept. 23-24, 1954	Recovered May 30, 1955
Number tagged	367	195 (53.1%)
Number untagged	367	186 (50.7%)

II. Simpson's Pond

——	Planted June 3-4, 1955	Recovered Sept. 20-22, 1955
Number tagged	333	233 (70.3%)
Number untagged	330	244 (73.9%)

Table II

Mean length and weight, with standard deviation, of tagged and untagged trout in ponds. Length in centimetres and weight in grams. Number of trout in samples in brackets.

I. Stevenson's Pond

	When planted Sept. 23-24, 1954		When recovered May 30, 1955	
	Tagged	Untagged	Tagged	Untagged
Mean length	22.6 ± 1.72 (200)	22.5 ± 1.95 (200)	26.2 ± 1.87 (191)	26.7 ± 1.75 (188)
Mean weight	139 ± 35.7 (200)	136 ± 39.1 (200)	203 ± 51.9 (190)	221 ± 47.3 (185)
Gain in length	—	—	3.6	4.2
Gain in weight	—	—	64	85

II. Simpson's Pond

	When planted June 3-4, 1955		When recovered Sept. 20-22, 1955	
	Tagged	Untagged	Tagged	Untagged
Mean length	17.1 ± 1.88 (333)	16.8 ± 2.45 (330)	21.4 ± 1.89 (230)	21.6 ± 2.58 (240)
Mean weight	62 (333)	60 (330)	122 ± 36.0 (178)	122 ± 46.2 (182)
Gain in length	—	—	4.3	4.6
Gain in weight	—	—	60	62

Table III

Relative heaviness, expressed by the condition factor K, of tagged and untagged trout.

I. Stevenson's Pond

	When planted	When recovered
Tagged	1.20	1.13
Untagged	1.20	1.17

II. Simpson's Pond

Tagged	1.25	1.24
Untagged	1.26	1.21

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Survival and Growth of Wild and Hatchery Rainbow Trout *(Salmo gairdnerii)* in Corbett Lake, British Columbia

by

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Many workers have shown that success of planting hatchery trout in streams is limited by a variety of conditions. It has also been clearly demonstrated that catches by anglers of planted fish may be expected to decrease rapidly in proportion to the lapse of time following release of the fish. At the same time, survival rate of hatchery trout through the winter months generally is very low. At least one of the causes of mortality following planting of hatchery trout in streams has been shown by Miller (1952) to stem from exhaustion of hatchery trout as they attempt to maintain themselves in a stream already populated by wild trout. Since Schuck (1948) and Miller (1952) have provided comprehensive literature reviews with their published works, it would appear to be unnecessary further to summarize the results of previous investigations on this problem. Data appear to be lacking on the survival of hatchery fish in lakes in which wild populations of the species to be planted already are established. Commonly it has been observed, for Centrarchidae at least, that where adequate natural spawning exists, little can be done by additional plantings from hatcheries to supplement natural production of wild stocks. Most of the lakes in British Columbia, which receive artificial plantings of hatchery trout, lack adequate spawning facilities or spawning streams are intermittent or marginal in nature. Generally these lakes are stocked with fry, unless they also contain predator or competitor species, in which case it has been the practice to plant larger fingerlings or yearling trout.

Some of the larger plantings of fingerling and yearling trout are made in lakes which also have good spawning streams and which support sizeable spawning runs of trout each year. The question arises as to whether it is economically feasible to supplement this natural production with hatchery plantings. Creel census records and marking experiments (Smith, 1955b) indicated a yield to anglers of planted yearling trout in at least one artificially stocked lake to be 30 per cent or greater in the first year following planting of hatchery fish. Additional data are required before it can be determined whether this rate can be equalled or exceeded in all artifically planted lakes in the face of completely unrestricted natural reproduction. It therefore becomes important that an understanding be gained of the factors affecting hatchery trout following release from an obviously artificial and protective environment, particularly if they are to be subjected to conditions under which they must compete with wild fish of their own species. The following summarizes data obtained from experimental plantings of wild and hatchery trout in a small lake in southern British Columbia.

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Parent Stock and Rearing Methods

Fish for the experimental plantings were obtained from wild stock at the B.C. Game Commission trout egg-station at Beaver Lake, near Kelowna, B.C. in 1952. Some of these fish were released as fry into natural ponds at Kelowna, while others of the same stock were reared at the B.C. Game Commission trout hatchery at Summerland, B.C. In May, 1953, about 3,000 yearling trout were removed from the Kelowna ponds and transferred to Summerland, where 1,500 were marked by removal of the right pelvic fin. At the same time, 1,500 yearlings of the same stock which had been reared at Summerland were marked by removal of the left pelvic fin. The two groups of fish were then transferred to the same holding pond and retained together for about 10 days, when they were released into Corbett Lake, near Merritt, B.C. At time of release, Kelowna fish averaged 7.2 cm. fork length, while the Summerland fish were 10.1 cm. fork length. In 1954 the experiment was replicated with 4,000 yearling fish from each group, reared from eggs taken at Beaver Lake in 1953. Kelowna fish in this case were 6.1 cm. fork length, while Summerland fish were 6.8 cm. long.

The following comparison of survival and growth of wild and hatchery trout illustrates probably the simplest situation which is practical to simulate. Wild trout in this case were subjected to an artificial environment only for two short periods, first, from the time the eggs were taken from wild parents in a natural spawning run, and second, for a period of about 10 days after the yearling fish had been transferred to the Summerland trout hatchery for marking and subsequent release. On the other hand, the hatchery trout were subjected to the protection of an artificial environment from the time eggs were taken until the fish were released in Corbett Lake.

Since the two groups of trout had similar parental backgrounds, it was to be expected that any possible differences in their reactions to a new environment should result from their histories between hatching and yearling age. It was further expected that results of the experiment should indicate whether the protective environment of the hatchery preserved undesirable qualities in the stock, thus postponing high mortalities from egg to yearling stage commonly observed in wild populations only until some date subsequent to release from the artificial environment.

Survival

Gillnet catches in 1953, 1954 and 1955 and anglers' catches in 1954 and 1955 provided specimens upon which all subsequent comparisons were based. Both of these sampling methods have disadvantages. First, where a considerable variation exists in the lengths of fish being sampled, the nets used in catching them may be selective as to size (Ricker, 1942). Secondly, it has been shown (Larkin and Smith, 1954) that intensive angling tends on the average to select faster growing individuals from any given age class during any particular period of the fishing season. Further, it has been found (Hiyama and Kusaka, 1952) that size of hooks used and skills of individual anglers also are selective as to size of fish caught.

Table I shows the occurrence of wild fish (Kelowna ponds) and hatchery-reared fish (Summerland hatchery) in 14 catches from 1953-55. Trout caught in 1953 had been resident in Corbett Lake for approximately 6 months and were classed as yearling

plus (I+). Those caught in 1954 were of the same age-group and were II+ when captured, while the fish which were captured in 1955 were II+ trout of the 1954 yearling stock. Many more samples, both in 1954 and 1955 were available from anglers' catches, but could not be included either because they were not complete records of all fish from individual catches or because scale samples from some of the 1954 and 1955 catches were not taken at the same time, and the ages of the fish were not known.

Table I

Occurrence of wild and hatchery trout in gillnet and anglers' catches in Corbett Lake, B.C.

Sampling method	Year captured and age	Occurrence of trout in samples		
		Summerland hatchery	Kelowna ponds	X^2 values
Gillnet	1953	7	9	6.256
Angling	I+	11	2	(P<0.02)
Gillnet	1954	4	3	
Gillnet	II+	2	13	
Angling	—	8	5	
Angling	—	3	2	27.456
Angling	—	0	8	(P<0.01)
Angling	—	7	1	
Angling	—	3	2	
Angling	—	0	6	
Total from 1953 stocking		45	51	
Angling	1955	6	11	
Gillnet	II+	17	9	9.958
Gillnet	—	9	7	(P<0.05)
Gillnet	—	0	6	
Total from 1954 stocking		32	33	

When *total catches* of wild and hatchery trout were compared (1953 stocking, I+ in 1953 and II+ in 1954; 1954 stocking, II+ in 1955) there was no significant difference in their numerical strength. Survival rate, as shown by total availability to capture, was therefore presumed to be equal in wild and hatchery fish for both stockings. However, from the X^2 values listed in Table I it is apparent that there was a significant departure from homogeneity in individual catches of the two groups of trout.

Objections probably could be raised for any method of sampling fish from a natural environment, and in this case was complicated by non-random occurrence of the two groups in the samples. Data presented here on total gillnet and angling catches both from 1953 and 1954 stockings offer a clear enough illustration of the total survival of the two groups of trout. Regardless of the degree to which various factors of sampling may have biased estimates of survival, the available evidence plainly lacks any significant indication of unequal survival of the two groups.

Growth Rates

Any attempts to describe and compare growth rates of the two lots of trout in Corbett Lake are complicated by the factors of selective sampling mentioned previously. However, since there were no significant numerical differences in the total catches, it was assumed that each lot of trout not only existed in equal strength, but also that each was equally available to capture by angling or by gillnetting. Growth rates of the respective age-groups therefore were compared directly, both for the 1953 and 1954 stockings.

Growth rates were calculated by use of the formula:

$$k = \frac{\text{Log}_e L_2 - \text{Log}_e L_1}{N}$$

where L_1 and L_2 represent calculated length (Smith, 1955a) at formation of first and second annulus respectively and N is equal to one year. Table II summarizes pertinent growth data for the two lots of trout, both from the 1953 and 1954 stockings.

Table II

Growth of wild and hatchery trout in Corbett Lake, B.C.

Source of Fish*	Year of capture	Mean fork length (cm.)			Instantaneous growth rate (k) from I to II	Number of fish in sample
		Age I (at release)	Age II	Age II+ (at capture)		
Summerland.....	1954	10.1	24.9	34.1	0.90	22
Kelowna.....	1954	7.2	17.2	28.9	0.87	11
Summerland.....	1955	6.8	14.4	25.0	0.74	34
Kelowna.....	1955	6.1	15.5	26.6	0.95	21

* *Summerland = hatchery reared trout; Kelowna = wild trout.*

The data summarized in Table II suggest that growth rates of wild and hatchery trout in Corbett Lake were very nearly identical for the first (1953) planting of 1,500 fish from each lot. In addition, the few III-year fish from the 1953 planting (5 hatchery and 6 wild trout) which were captured in 1955 exhibited remarkably uniform size. Trout of this age-group from Kelowna ponds averaged 41.0 cm. in length with a range in length of only 3.6 cm., while Summerland fish averaged 40.6 cm. with a range in length of 5.1 cm. Data from the second (1954) planting of 4,000 fish of each group indicated that when the two lots of trout were released at more nearly the same size, the wild-reared trout had a significantly higher growth rate ($P < .05$) for the first year in the lake. Although the two lots of trout in the 1954 planting did not differ significantly in mean length at any age, the wild fish were 0.7 cm. smaller than the hatchery fish at time of release and were 1.1 cm. larger at the end of their second year. Unfortunately,

data are not available for comparisons of growth between ages II and III of the wild and hatchery fish of the 1954 plantings, since Corbett Lake "winter-killed" during the winter of 1955-56.

Discussion

It would appear from data in Table II describing mean lengths at release and subsequent rates of growth of wild and hatchery fish, that wild-reared fish, which possibly are better able to compete, grow faster under natural conditions than hatchery fish from the same parental stock. Whether wild fish in this case were better adjusted to a natural environment prior to release or whether a proportion of "weaklings" were preserved by hatchery rearing (where mortality from egg to yearling was less than 15 per cent in each of the two years) it is not possible to state. From the results of sampling, which showed a rather sharp dissociation of each group of trout (lack of homogeneity in occurrence in samples) it is likely that the two groups of trout were differently conditioned in one way or another in their early life.

Although detailed costs for each operation are not given here, cost *per yearling trout* was about 40 per cent higher for Kelowna pond fish than for trout raised in Summerland hatchery. Cost *per pound* of Kelowna fish was about 3.5 times greater than cost per pound of Summerland hatchery fish. Since the key factor in trout production is the ultimate yield of fish to anglers, probably the most effective basis for comparing efficiency of the two operations would be on the basis of cost *per fish* produced. This becomes evident from equal survival (availability to anglers) of individuals of the two groups of trout following stocking.

Aside from practical considerations of comparative costs of rearing and survival and growth after release of wild and hatchery trout, the results of sampling point out the importance of behaviour of individuals of the two groups. Corbett Lake is a relatively small body of water (50 acres) and typical of many lakes of the interior of British Columbia in which yearling trout are planted each year. It was selected for the experiment chiefly to minimize sampling problems. At the same time, the two groups of trout in both years were held together and fed the same food at Summerland hatchery for at least ten days before being released, to preclude the possibility of bias from temperature and diet acclimation. Nevertheless, it is evident that members of each group either aggregate in such a way that they are susceptible to capture as schools, or tend to exclude interchange of members between schools. The results of this experiment suggest that where survival, growth and behaviour of wild fish of any species are being assessed, either by comparison with hatchery-raised fish or by handling of wild stocks, an awareness of possible conditioning of young fish during early life or at time of handling is of considerable importance.

During the past few years considerable work has been done in evaluation of fish cultural practices, both in methods of rearing game fish in hatcheries and in assessment of planting requirements for angling waters. Dr. R. B. Miller's series of experiments with hatchery trout in Alberta streams has clearly shown that hatchery trout have a very low survival when forced to compete with wild trout in streams. Dr. Miller's experiments suggest that planting of hatchery trout in streams can be justified only in special circumstances, such as stocking a stream barren of fish life or planting catchable

trout for the immediate demand of heavy angling pressure. The present experiment would appear to indicate that conditions limiting survival of trout in lakes likely are not as stringent, and that hatchery trout are as well able to utilize the resources of a natural lake environment as are wild trout of the same size and age. It is therefore apparent that where a heavy demand exists for angling in lakes, the presence of wild trout does not preclude the possibility of supplementing stocks by hatchery plantings.

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Increase in Levels of Lactic Acid in the Blood of Cutthroat and Steelhead Trout Following Handling and Live Transportation

by

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There are many causes of death of fishes such as adverse temperature changes, lack of oxygen, and metallic poisoning. In addition to these causes, the view was put forward by Black (1956) that the increased production of lactic acid and other changes following vigorous muscular activity may be the cause of death in the so-called delayed planting mortality in salmonoids reported by Horton (1956), Miller (1951) and Wales (1954). Black's contention rests on the observation that lactic acid increased in the blood of Kamloops (*Salmo gairdnerii*) and lake trout (*Salvelinus namaycush*) following live transportation, and on the earlier observations of von Buddenbrock (1938), Huntsman (1938) and Secondat and Diaz (1942) that death in fishes followed vigorous muscular activity.

In a recent paper, Miller (1955) showed that death of yellowstone cutthroat, *Salmo clarki lewisi* (Girard), occurred when the fish were transported and planted in a stream containing resident cutthroat trout. However, mortalities were no greater than 13 to 16 per cent when fish were transported and planted in a section of the stream free from trout. Miller noted that death was possibly due to exhaustion but no biochemical tests were performed. It would appear then that death may be due to muscular exercise resulting from activity induced during handling, transportation, and subsequent activity in the new environment.

Nielson *et al* (1957) have recently demonstrated that there is no significant difference in the survival of hatchery raised rainbow trout (*Salmo gairdnerii*) and resident wild brown trout (*Salmo trutta*). However, if improper diet for the hatchery fish is used, losses subsequent to planting may be considerable (Wales, 1944.)

Nielson (1957) has not found any losses of rainbow trout which could be attributed to handling, marking and transportation. These studies extended over a period of $6\frac{1}{2}$ years at Convict Creek Station, California. Delayed planting mortality following transportation may occur only under special circumstances and by the use of special care in feeding (Wales, 1944) and by controlling the temperature (Horton, 1956) the incidence of mortality may be reduced.

In the present study, hatchery raised coastal cutthroat trout, *Salmo clarki clarki* Richardson, and steelhead trout, *Salmo gairdnerii*, were used. The effects of handling, such as the capture and transferring of fish from an outside pond to an inside hatchery

trough were examined. The influence of holding the fish in the hatchery for one to two days before transportation was investigated. Finally, the effect of an immediate sham transportation run in a tank truck from the outside and a subsequent return to inside hatchery trough was examined. Cutthroat trout were selected for the reason that the related subspecies, the yellowstone cutthroat trout, reared in hatchery may suffer 100 per cent mortality after planting (Miller, 1951). As steelhead trout were available, they were used for comparison with the cutthroat trout.

Evidence has been obtained in the present paper that significant activity does result from handling of fish as well as from transportation. However, no unequivocal evidence has been obtained that the increase in the blood level of lactic acid during transportation is the cause of delayed planting mortality.

Methods

Yearling and two-year-old cutthroat and yearling steelhead trout were used. All fish had been reared at the Smith's Falls Trout Hatchery, which is operated by the British Columbia Game Commission at Cultus Lake, B.C. Weights of the fish used are given in the tables. The blood changes resulting from handling and the sham transportation run were studied at Smith's Falls. Certain transportation hauls were made from the Smith's Falls Hatchery to the experimental laboratory of the Institute of Fisheries of the University of British Columbia, a distance of 70 miles = 112 kilometres. The tank truck used for the transportation experiments was the same one described in the previous study (Black, 1956a). Certain details of the methods of handling and storage will be given later.

The method of taking blood samples by cardiac puncture while the fish respired in water has been already described (Black, 1955), as were the procedures for the determination of hemoglobin and lactic acid. When blood samples were taken at Smith's Falls Hatchery, the hemoglobin determinations and the precipitation of the protein were carried out at Smith's Falls. The tungstic acid filtrates were analyzed at the Institute of Fisheries on the following day. Mortalities in control groups were also recorded for the fish reported in Tables VI and VII.

Results

I. Alterations in blood level of lactic acid in salmonoids following vigorous muscular activity.

Immediate increase in the blood lactic acid level of yearling and two-year old Kamloops trout following 15 minutes of vigorous exercise is shown in Table I. For example in yearling Kamloops trout the lactic acid increased from the unexercised level of 15.7 mg. % to 99.8 mg. %. During the recovery period the blood level continued to increase up to 170 mg. % at the end of two hours. Ultimately, the lactic acid returned to near-resting level, and after 24 hours of recovery was 16 mg. %. Full description of changes are given in the paper by Black (1957).

Similar changes were noted for the two-year old Kamloops trout. However, in all cases the blood level of lactic acid was somewhat lower than in yearlings.

The blood level of cutthroat trout following 15 minutes vigorous exercise was 85.7 mg. % for yearlings and 72.9 mg. % for two year olds, while the value for yearling steelhead was 113.0 mg. %. These values are not greatly different from those for the respective age groups of Kamloops trout.

It was not possible to obtain values for the unexercised condition in cutthroat and steelhead trout. As an approximation, the values for 24 hours recovery from a transportation run from the Smith's Falls Hatchery at Cultus Lake to the Institute of Fisheries at Vancouver are given. It will be noted that these values are low compared with the values for the 24 hour recovery period after vigorous exercise. As will be discussed in Section IV, the fish brought to the Institute of Fisheries were probably never in a resting condition, so that these low values may mean that the lactic acid precursor had not been resynthesized to any large extent.

Table I

Weights and blood levels of hemoglobin and lactic acid in trout following various conditions.

Standard error of the average is given after the average.

Species and Condition	Year	No. of fish	Average weight g.	Average hemoglobin g.	Average blood lactic acid mg.%
Kamloops trout, yearling					
Unexercised	1953/54(*a*)	41	57±2.0	11.0±2.0	15.7±1.09
Exercised	1953/54(*a*)	35	57±3.2	10.7±0.23	99.8±0.95
Recovered 2 hrs. after exercise	1953/54(*b*)	10	82±6.0	11.0±0.60	170±9
Recovered 24 hrs. after exercise	1953/54(*b*)	11	70±2	11.2±0.3	16.0±2.2
Kamloops trout, 2 year old					
Unexercised	1954 (*a*)	11	125±17.8	10.1±0.43	8.0±0.95
Exercised	1954 (*a*)	11	134±12.3	11.2±0.30	82.2±10.0
Recovered 2 hrs. after exercise	1955 (*b*)	6	167±34.5	14.8±0.57	117±10.8
Recovered 24 hrs. after exercise	1955 (*b*)	9	151±10.4	15.3±0.41	11.1±1.35
Steelhead trout, yearling					
Rested 24 hrs. after transportation	1956	5	54.2±1.7	12.7±0.49	4.0±1.0
Exercised	1956	9	44.3±1.4	13.0±0.47	113±30.5
Cutthroat trout, 2 year old					
Rested 24 hrs. after transportation	1956	5	90.2±3.44	15.0±0.49	1.02±0.38
Exercised	1956	7	117.7±12.2	11.1±0.4	72.9±2.3
Cutthroat trout, yearling					
Exercised	1956	10	37.6±1.9	10.6±0.2	85.7±4.3

(*a*) Black 1955.
(*b*) Black 1957a.

These values in Table I will be used as a basis for comparison in interpreting the lactic acid values reported in Tables II–VII inclusive.

II. Effect of handling fish on the blood level of lactic acid.

In the previous paper (Black, 1956a) on the effects of transportation, no effort was made to determine the importance of the handling procedures themselves on inducing muscular exercise and hence in raising the blood level of lactic acid. As is well known by those who constantly work with live fish, nearly every change in the external environment may startle fish or otherwise increase their activity. The following steps in capturing and transferring the fish may all cause an increase in muscular activity: (1) Hatchery attendants appearing at the pond; (2) removing the pond cover; (3) lowering the water level to facilitate capture; (4) capturing the fish by means of a dip net; (5) transferring the captured fish to a pail; (6) carrying the pail to hatchery trough (in this case the distance was 60 yds. = 54.9 metres); (7) liberating the fish into the trough, and (8) subsequent holding in the hatchery trough. In an actual transportation run, some of the last few steps probably would be left out.

A. CUTTHROAT TROUT.—The relation of the above handling procedure to the blood level of lactic acid in two-year old cutthroat trout is shown in Table II, Column 5. These values may be compared with those for completely rested fish given in Table I. However, it is important to point out that these resting values are unexpectedly low, as compared with two-year old Kamloops trout. After 15 minutes vigorous exercise the blood lactic acid level was 72.9 mg.% (Table I).

In 7 cases out of 9 in Table II, the lactic acid values are increased significantly. In 5 of 9 readings, the values are higher than 20 mg.%. However, only in one case was the level above the 50% average for fully exercised cutthroat trout.

Table II

Weights and blood levels of hemoglobin and lactic acid of cutthroat trout at various times following the transferring of two year old cutthroat trout from outside ponds to a trough inside the hatchery at Smith's Falls, B.C. (Temperature 46° F. = 7.8° C.)

Experiment Number	Time elapsed after transfer complete	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
2	1	98	10.7	21.7
4	7	157	15.1	7.7
6	14	172	11.1	22.2
10	37	210	14.3	5.8
14	63	205	9.1	56.5
18	91	136	10.4	14.9
22	119	132	10.2	24.4
26	104	85	11.2	22.4
36	214	121	13.8	14.5

No control fish were held to determine the possible mortality from the handling, capturing, transfer, and confinement in the hatchery troughs.

It is concluded that handling procedures, including confinement, result in muscular activity as judged by significant increases in the blood level of lactic acid.

B. STEELHEAD TROUT.—The relation of handling procedures on the blood level of lactic acid in yearling steelhead trout is shown in Table III, column 5. In 8 of the 9 readings, there was a significant increase in lactic acid above the average for condition of recovered fish (Table I). In 6 of the 9 cases, the values were 30 mg.% or higher (Table III). That is, the values were 10 mg.% or higher than the two-year old cutthroat (Table II). In 2 cases out of 9, there were increases in lactic acid above the 50% level for steelhead exercised vigorously for 15 minutes (Table I). The differences may be due to size, for Black (1955) found that the blood levels in two-year old Kamloops trout were lower than yearlings. The differences noted could also be due to species differences in behaviour, muscle glycogen levels and circulation.

No control fish were held to determine the possible mortality from the handling, capture, transfer and confinement.

It is concluded that handling results in increased muscular activity as shown by the very significant increase in lactic acid of the blood in yearling steelhead trout.

III. Effect of immediate transportation on the blood level of lactic acid.

Fish were taken from outside ponds at the Smith's Falls Hatchery and then placed in the tank truck and transported on a sham run for two hours. The sham run was identical to a routine liberation, except that the fish were returned to the hatchery. On return, the fish were placed in troughs inside the hatchery.

Table III

Weights and blood levels of hemoglobin and lactic acid of yearling steelhead trout at various times following the transferring of the trout from outside ponds to a trough inside the hatchery at Smith's Falls, B.C. (Temperature 46°F. = 7.8°C.)

Experiment Number	Time elapsed after transfer completed	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
1	2	47	14.6	36.5
3	16	47	11.1	21.1
5	24	50	12.7	30.6
7	41	40	11.8	34.1
13	72	42	11.9	44.4
17	101	42	12.6	23.7
21	126	54	9.9	53.5
25	154	48	8.8	8.7
35	224	42	10.9	35.4

A. CUTTHROAT. In this experiment, yearling cutthroat were used since the supplies of two-year old cutthroat were exhausted. In 13 of the 17 readings, the blood level of lactic acid following the sham transportation run was 28 mg.% or higher (Table IV). In 7 cases out of 17, the concentration of lactic acid was greater than a half load for yearling cutthroat trout following 15 minutes of exercise (Table I). In 2 cases out of 17 the lactic acid was near a full load, namely nearly 83 mg.%. In one case, where the sample was taken $2\frac{1}{2}$ hours after the run was completed, the lactic acid level was 106 mg.%. The blood levels of lactic acid were substantially higher and persisted for a longer time than those noted for either the year-and-one-half-old lake trout or two-year-old Kamloops trout (Black, 1956a).

If the results for the handling alone (Table II) are subtracted from those for the handling plus the transportation run (Table IV), it is clear that there is a significant increase that must be attributed to the transportation factor alone. A strict comparison, however, is not warranted, since the two groups differed in age. The younger group which showed the higher values was used for the sham run. Moreover, the time course of the appearance and subsequent disappearance of blood lactic acid following activity does not warrant comparison between Tables II and IV.

No control fish were held to determine the possible mortality from capturing, sham transportation and subsequent holding.

It is concluded that live transportation of yearling cutthroat resulted in considerable muscular activity as judged by the very significant quantities of lactic acid which appeared in the blood.

Table IV

Weights and blood levels of hemoglobin and lactic acid of yearling cutthroat trout, at various times following sham transportation for two hours. Smith's Falls, B.C. (Initial temperature 51.8°F. = 11.0°C., final temperature 55.4°F. = 13.0°C.)

Experiment Number	Time elapsed after run completed	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
12	10	33	10.4	31.7
14	16	47	8.9	83.3
16	23	29	8.6	52.4
18	35	31	9.9	42.5
20	47	58	9.6	68.1
22	52	37	9.0	34.0
24	60	45	10.9	27.6
26	83	51	10.6	10.2
28	90	42	—	88.0
30	98	35	10.3	40.0
32	105	36	—	32.8
34	114	33	9.0	68.7
36	120	49	10.3	60.7
38	133	37	—	15.6
40	140	52	10.7	12.8
42	147	35	9.4	106.0
44	155	46	11.8	19.9

B. STEELHEAD. In 12 cases out of 17, the blood lactic acid in yearling steelhead following two hours of live transportation was 28.7 mg.% or greater (Table V). In 9 cases there was greater than a half load of lactic acid found in steelhead trout vigorously exercised for 15 minutes (Table I). In two cases, the lactic acid levels were 111.5 and 115.0 mg.%. While the blood levels of lactic acid begin to fall at the end of 2 hours after transportation, the highest value recorded was for the sample drawn 129 minutes after the trip was completed.

In considering the effect of handling on the blood level of lactic acid in steelhead (Section IIB and Table III) it would appear that approximately one third of the lactic acid following transportation might be attributed to handling alone. Evidently transportation alone is associated with a significant increase in blood lactic acid.

The lactic acid levels observed in the yearling steelhead were greater and persisted for a longer period than those recorded for lake trout and Kamloops trout (Black, 1956a).

No control fish were held to determine the possible mortality from capturing, sham transportation and subsequent holding.

From the above observations, it is concluded that sham transportation of yearling steelhead resulted in significant muscular activity, as judged by the quantities of lactic acid which appeared in the blood.

Table V

Weights and blood levels of hemoglobin and lactic acid of yearling steelhead trout at various times following sham transportation for two hours. Smith's Falls, B.C. (Initial temperature 51.8°F. = 11.0°C; final temperature 55.4°F. = 13.0°C.)

Experiment Number	Time elapsed after run completed	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
11	7	43	10.9	16.1
13	13	42	11.5	40.1
15	19	45	10.4	65.0
17	31	43	10.6	56.9
19	43	35	—	35.7
21	49	43	11.3	35.2
23	56	35	11.5	70.6
25	78	51	10.8	13.0
27	87	41	12.2	39.1
29	95	45	9.1	111.5
31	102	36	10.8	28.7
33	110	42	8.9	71.3
35	117	40	9.4	11.9
37	129	45	9.9	115.0
39	137	46	11.0	17.5
41	143	34	11.5	11.1
43	151	47	12.0	40.7

IV. Influence of holding trout 1 to 2 days after initial capture on the blood levels of lactic acid following transportation in tank truck.

Trout were taken from the outside ponds and transferred by pails to inside troughs at the Smith's Falls Hatchery. The cutthroat trout were stored two days (40 hours), and the steelhead trout 1 day (16 hours) before transportation in the tank truck to the Institute of Fisheries at the University of British Columbia. The transportation run occupied 2 hours and 50 minutes. At the Institute of Fisheries the fish were transferred to 6 tanks measuring $19\frac{1}{2}$ x 17 x 14 inches = 49.5 x 43.2 x 35.5 cm. There are the following differences in experimental treatment from Section III:

(1) The fish were held for 16 hours (steelhead) or 40 hours (cutthroat) after capture from the ponds and before transportation.

(2) The fish were transported for 2 hours and 50 minutes.

(3) The fish were transferred to small tanks rather than standard hatchery troughs.

(4) The fish were placed in Vancouver city water that had been passed through a dechlorinator.

A. CUTTHROAT TROUT. The lactic acid levels of the blood of the two year-old cutthroat trout following holding for 40 hours and subsequent transportation in a tank truck for 2 hours and 50 minutes are low (Table VI). The values are actually lower than those in Table II where no transportation or holding were involved. Two explanations are offered for the low blood levels of lactic acid following the above experimental conditions: (1) It is possible that the fish were not active. (2) It is possible that the fish continued to swim vigorously and sufficiently to deplete most of the glycogen stores and that most of this presumed activity occurred at least 12 hours before the transportation run. Thus the lactic acid, if produced, would have disappeared.

The second explanation is the one which is considered the more likely. This opinion is based on the following evidence. When fish from the above sample were vigorously exercised for 15 minutes the day following transportation, the average value for 5 readings was 15.5 $\pm$ 7.8 mg.%. Indeed, only one value of 46.6 mg.% was higher than the average. The second piece of evidence is drawn from work on Kamloops trout which indicates that it may take more than a week to restore the initial glycogen level (based on lactic acid yields) after 15 minutes of vigorous activity (Black, 1956b).

Fontaine and Hatey (1953) in their study of the carbohydrate changes in adult migrating Atlantic salmon, *Salmo salar*, showed that the content of muscle glycogen is very variable and that there was no significant reduction of muscle glycogen during the ascent up river despite the fact that feeding had stopped on leaving salt water. These studies indicate that no final inference should be drawn about the content of muscle glycogen till direct analyses are made.

It is concluded from these experiments that the glycogen, once expended, may take days to be resynthesized to the initial level.

The 50 control cutthroat trout that were held for 40 hours, transported to the Institute of Fisheries and then held in the small tanks did not fare well. All were dead within a week. This death cannot be associated with high levels of lactic acid in the

blood, for in samples taken on the first and second days, none of the 7 examined showed a lactic acid level higher than 12.6 mg.%, even though the cutthroat appeared to be constantly active in holding tanks as judged by efforts to escape and frequent bumping nto sides of tank.

Table VI

Weights and blood levels of hemoglobin and lactic acid of two year old cutthroat trout removed from outside ponds and held for 40 hours in the hatchery before transporting, for 2 hours and 50 minutes, from Smith's Falls Hatchery to the Institute of Fisheries, University of British Columbia at Vancouver. (Initial temperature 46°F. = 7.8°C.; final temperature 53.5°F. = 11.9°C.)

Experiment Number	Time elapsed after run completed	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
1	10	98	14.8	17.5
3	18	267	14.2	4.3
5	32	104	11.1	6.5
7	36	228	11.0	6.7
9	41	112	10.8	12.2
11	50	120	8.1	15.1
13	58	53	14.0	3.5
15	67	104	12.9	14.6
17	76	67	13.3	3.9
19	81	107	15.2	4.2
21	87	126	14.1	0.8
23	97	113	12.1	2.4
25	103	104	12.0	8.2
27	113	90	14.8	5.8
29	122	119	12.8	4.4
31	130	100	13.4	3.5

B. STEELHEAD. The treatment for these yearling steelhead was precisely as above except that these were held in troughs at Smith's Falls only 16 hours prior to transport to the Institute of Fisheries. These were brought in in the same tank truck as the cutthroat and were held in three small tanks at the Institute of Fisheries.

Very significant quantities of lactic acid were found to be present in the blood right up to the end of 2 hours (see Table VII). All the steelhead controls also died within 10 days. Moreover, it appeared that the steelhead reacted violently to their small enclosure, but less frequently than the cutthroat. Here, then, death following transport appears to be associated with lactic acid in the blood, following handling and a day's rest at Smith's Falls, and transport from Smith's Falls to the Institute of Fisheries. There are still the differences to be explained between these data and those for the cutthroat trout. When a sample of these steelhead were exercised for 15 minutes, 48 hours after transportation, the average lactic acid was 46.7 $\pm$ 5.0 mg.%. However, the value obtained for steelhead at Smith's Falls which had *not* been subjected to transportation was 80.8 $\pm$ 6.0 mg.% (Table I). The steelhead then, either had not been so active or had resynthesized glycogen at a faster rate than the cutthroat.

Table VII

Weights and blood levels of hemoglobin and lactic acid of yearling steelhead trout removed from outside ponds and held for 40 hours in the hatchery before transporting, for 2 hours and 50 minutes, from Smith's Falls Hatchery to the Institute of Fisheries, University of British Columbia at Vancouver. (Initial temperature 46°F. = 7.8°C.; final temperature 53.5°F. = 11.9°C.)

Experiment Number	Time elapsed after run completed	Weight	Hemoglobin	Lactic acid
	Minutes	Grams	Grams per 100 cc.	Milligrams per 100 cc. of whole blood
2	15	57	9.9	31.9
4	21	53	9.1	59.0
6	34	65	8.5	60.7
8	39	57	8.0	42.7
10	44	59	10.3	21.0
12	53	56	8.1	35.4
14	60	56	10.1	48.2
16	70	56	8.5	51.2
18	79	72	11.1	54.2
20	85	53	11.4	71.4
22	90	63	8.3	37.8
24	101	58	10.0	51.3
26	105	64	10.2	88.0
28	120	59	11.8	11.0
30	125	53	10.3	59.2
32	133	54	14.7	9.5

These experiments show that increased lactic acid is associated with death in the steelhead trout. It is admitted, however, that death of the control fish may not have been due to transportation alone.

Secondly, it is concluded that, as was the case with the cutthroat, recovery from muscular fatigue may not only involve removal of the lactic acid from the blood, but a slow regeneration of the muscle glycogen.

Commonly it was the practice in some hatcheries to exercise fish by lowering the water for a few minutes each day for a few days previous to liberating them. It is thought that the basis for this practice should be systematically investigated by observing not only changes in the blood biochemistry but also in making observations on behaviour and survival.

Summary

Alterations in the blood levels of lactic acid were investigated in hatchery raised cutthroat and steelhead trout in the following conditions:

A. After transferring from outside ponds to troughs inside the hatchery 60 yards = 54.9 metres away.

B. Sham transportation run for two hours in tank truck.

C. Holding cutthroat for 40 hours, steelhead for 16 hours in hatchery troughs before transportation run of 2 hours 50 minutes.

The following results were noted:

(1) Significant increases in blood lactic acid occurred in both species as a result of minimal handling, i.e. in transporting the fish from outside ponds to inside hatchery troughs.

(2) Very significant increase in blood levels of lactic acid following sham transportation run for 2 hours in a tank truck. The levels were higher in both species than those observed for lake trout and Kamloops trout in 1955.

(3) Storage of cutthroat for 40 hours resulted in significant lowering of blood level of lactic acid (range 0.8 — 17.5 mg.%) following transportation run of 2 hours and 50 minutes.

Storage of steelhead trout for 16 hours before the same transportation run of 2 hours and 50 minutes resulted also in a lower blood level of lactic acid (range 9.5 — 88 mg.%).

Conclusions

A. It is concluded that even minimal handling caused significant increase in muscular activity both for cutthroat and steelhead trout.

B. Handling and live transportation for 2 hours caused a very significant degree of muscular activity.

C. It is concluded that previous history of activity may result in lowered blood levels of lactic acid following a second phase of activity. It is possible that this phenomenon may be due to a very slow rate of resynthesis of muscle glycogen. It is possible that if the muscle glycogen is depleted and takes a long time to be resynthesized, this may have some bearing in the conditioning of fish by exercise previous to liberation.

Acknowledgments

The authors gratefully acknowledge the assistance and encouragement provided by Frank Pells, Hatchery Supervisor in charge of the Smith's Falls Trout Hatchery; technical assistance provided by F. D. Forbes, A. Hanslip and K. Henze of the Department of Physiology. The facilities provided by the Provincial Game Commission, through Commissioner F. R. Butler and Robert McMynn, and the Institute of Fisheries of the University of British Columbia through the director, Dr. P. A. Larkin are acknowledged. The National Research Council of Canada provided a grant-in-aid to the senior author for the support of the technical assistance provided by Messrs. Forbes and Hanslip, and other expenses. The Research Committee of the University of British Columbia provided a special water dechlorinator used during this study.

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Introduction of the Hybrid Between the Eastern Brook Trout and Lake Trout into the Great Lakes

by

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In May, 1954, the Ontario Department of Lands and Forests stocked 7,135 marked yearling hybrids between the eastern brook trout *Salvelinus fontinalis* (Mitchill) and the common lake trout *Salvelinus namaycush* (Walbaum) in South Bay in northern Lake Huron. An experimental fishery is being carried on in South Bay by the Department's Research Division. It was hoped that this fishery would afford a chance to examine a sample of the hybrids as they became large enough to be taken in the gear being used.

Stenton (1950, 1952) has described the cross made between the two species at Banff, and the subsequent introduction into some of the Jasper Park lakes. Introductions have also been made in a number of inland lakes in Ontario and in several of the northern states (Scott, 1956) but so far as is known, no other introductions have been made in the Great Lakes or their tributary waters. Careful documentation of all new introductions into these international waters is highly desirable.

The parent stocks were wild female lake trout taken during lake trout spawning operations on the Montreal River, a stream flowing into the east shore of Lake Superior about eighty miles north of Sault Ste. Marie, Ont., and hatchery reared male brook trout. The cross was made at the Tarentorus hatchery near Sault Ste. Marie in early October, 1952. The eggs hatched during the winter of 1952-53 and the fry were reared according to standard hatchery procedure. In August, 1953, the fingerlings were transferred to a trout rearing station at Chatsworth, Ont., where they were held until the introduction was made. The fish were marked by removal of the right pectoral fin and planted in South Bay on May 19 and 20, 1954. The planting was done from a slowly moving boat, the fish being scattered in the shallow water over gravel and rubble bottom areas at the rate of about 2,000 fish per mile of shoreline. A small sample was measured and preserved for future comparison. This sample averaged 3.8 inches in fork length, and is considered to be representative of the entire lot.

Recaptures

No hybrids were captured during rather extensive netting with small-mesh gillnets in the summer and fall of 1954. The first hybrids were taken in the first lift of pound nets on May 13, 1955, almost exactly one year after the original stocking. Except for some specimens preserved for study purposes, the fish were measured to the nearest half inch, tagged with streamer type plastic tags and released at the site of capture. Growth for the first year in the lake had been rapid. The 77 fish measured

in May averaged 13.9 inches in fork length with a range of from 11.5 to 17.0 inches. Native lake trout of the same age in South Bay (Fry 1953) were found to average only 10.0 inches in fork length.

The total number of hybrids tagged during May, June and early July was 229. Recaptures in South Bay through November, 1955, numbered 99 individual fish or 43.2 per cent of those tagged. Seventy-one were recaptured once, 17 twice, seven three times, three four times and one five times. This is a rather high recapture rate when compared with other species in South Bay and recapture rates reported by other investigators. The recapture pattern for fish taken in pound nets suggests that they do much moving. One fish was recaptured five times in three widely separated nets over a twenty-day period. As the surface water warmed the hybrids moved into deeper water. In general, however, they did not go as deep as the lake trout and were taken in depths of from eight to 12 fathoms or in the region of the thermocline. In late October and early November ripe male hybrids were taken on shoals where lake trout were known to have spawned in past years. No mature females were taken, which is not unusual since in many species of fish the males mature a year before the females.

The recapture of tagged hybrids from outside South Bay presents a very interesting and rather unexpected picture. It should again be noted that the female parents were

from a river spawning race of trout. River spawning is rather uncommon in lake trout and only six such runs are known to occur in the Great Lakes. These are all in the eastern half of Canadian Lake Superior waters, and at present are being rapidly depleted by the sea lamprey.

Seven tags were returned from outside South Bay and several reports of untagged hybrids were received but not verified. It is of interest that in one instance, when a hybrid was taken alive in a pound net by a commercial fisherman, there was some discussion as to whether the fish was a lake trout or a brook trout. The solid circles on the map denote the location of capture of tagged hybrids.

Two of the tagged recaptures were taken in streams, one from the Manitou River, the other from the Mindemoya River. These are both small rivers that flow into Lake Huron on the south shore of Manitoulin Island, five and 15 miles west of the entrance to South Bay. The fish from Mindemoya River was taken about two miles up from the mouth, while the one from the Manitou River was taken about 10 miles upstream near where the river begins as the outflow from Lake Manitou. A third hybrid was taken off the mouth of the Mindemoya River by a commercial fisherman.

Two other tags were returned from pound nets fished in Owen Channel on the east shore of Manitoulin Island about 15 miles east of the South Bay entrance. One of these fish was released alive on June 29 and recaptured again in South Bay on October 24, 1955.

Two additional tagged hybrids were taken in the west end of the North Channel near Thessalon. These fish had travelled a distance of about 100 miles from South Bay, one in 20 days, the other in 116 days.

In addition to the recapture of the tagged hybrids, reports of the untagged hybrids have been received from the Saugeen River, from the area east of Killarney, and the Key Harbour area in the north-east corner of Georgian Bay. These locations are designated on the map by open circles.

Limited observations suggest that smelt and alewives form major items in the diet of the hybrids. In Lake Huron and Georgian Bay there is a large, and at present, unutilized population of both smelt and alewives that could serve as an ideal source of food for any predatory fish that can withstand the current level of lamprey predation. It is hoped that the hybrids may prove to have an advantage in this respect because of their more rapid growth rate and the earlier age at which they attain maturity. It is expected that both males and females will be mature in the fall of 1956, and possible spawning activity at that time will be of major interest.

Summary

Marked yearling hybrids between eastern brook trout and common lake trout were planted in South Bay in northern Lake Huron in the spring of 1954. Growth was rapid and after one year in the lake the hybrids averaged 13.9 inches in fork length. A number of the fish were tagged and subsequent recapture data recorded. Seven tags were returned from distances up to 100 miles. Two of the tagged fish had entered streams while the other five were taken by commercial gear. Ripe male hybrids were taken in South Bay during late October and early November.

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Management, Fishing Results and Growth of Speckled Trout *(Salvelinus fontinalis)* in Baldwin Pond, Stanstead County, Que.

by

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At one time Baldwin Pond (Fig. 1) had the environment favourable to speckled trout. Unfortunately, its sport value was decreased by a single factor: the introduction of unwanted species of fishes with consequent serious reduction in the number of trout. To restore the lake to its former suitability for speckled trout for angling, it was necessary to take appropriate management measures.

Management

In the fall of 1953, a complete poisoning of Baldwin Pond took place to destroy undesirable species, making it possible to recondition the lake for speckled trout angling.

Plantings, made from the Eastern Townships Fish Hatchery, were as follows:

Spring 1954:	20,000 yearlings (7-9 inches)	Not marked
Fall 1954:	5,000 fingerlings (5-6 inches)	Left pectoral fin removed
Spring 1955:	2,500 yearlings (6-7 inches)	Right pectoral fin removed

Three distinctly marked plantings of speckled trout were available for study when the first day's angling was allowed in the lake on May 23, 1955.

Fishing Results

Two biologists of the Quebec Biological Bureau, Raymond Desrochers and the author, went to the lake on May 23 and 24 to investigate fishing results and methods, and to gather pertinent data on the behaviour of the planted trout. The actual creel census, and the organization of the many factors which made it possible, was a co-operative undertaking of the technicians of the Eastern Townships Fish Hatchery, directed by Louis-Roch Séguin; the local fish and game warden, Seth Blake and members of the Stanstead County Fish and Game Club. Mr. Blake undertook, during the entire season, to gather daily fishing data on the number of anglers, the number of fish caught, and the number of fishing hours per angler.

Control was made easier by the fact that access to the lake is usually confined to one place. Fishing from the banks was not allowed, and fishing hours were defined as between 5:00 a.m. and just after sunset. The creel limit was ten fish per angler per day. Statistics were facilitated by the fact that boats were rented by the hour and those bringing their own boats were registered and charged a small fee.

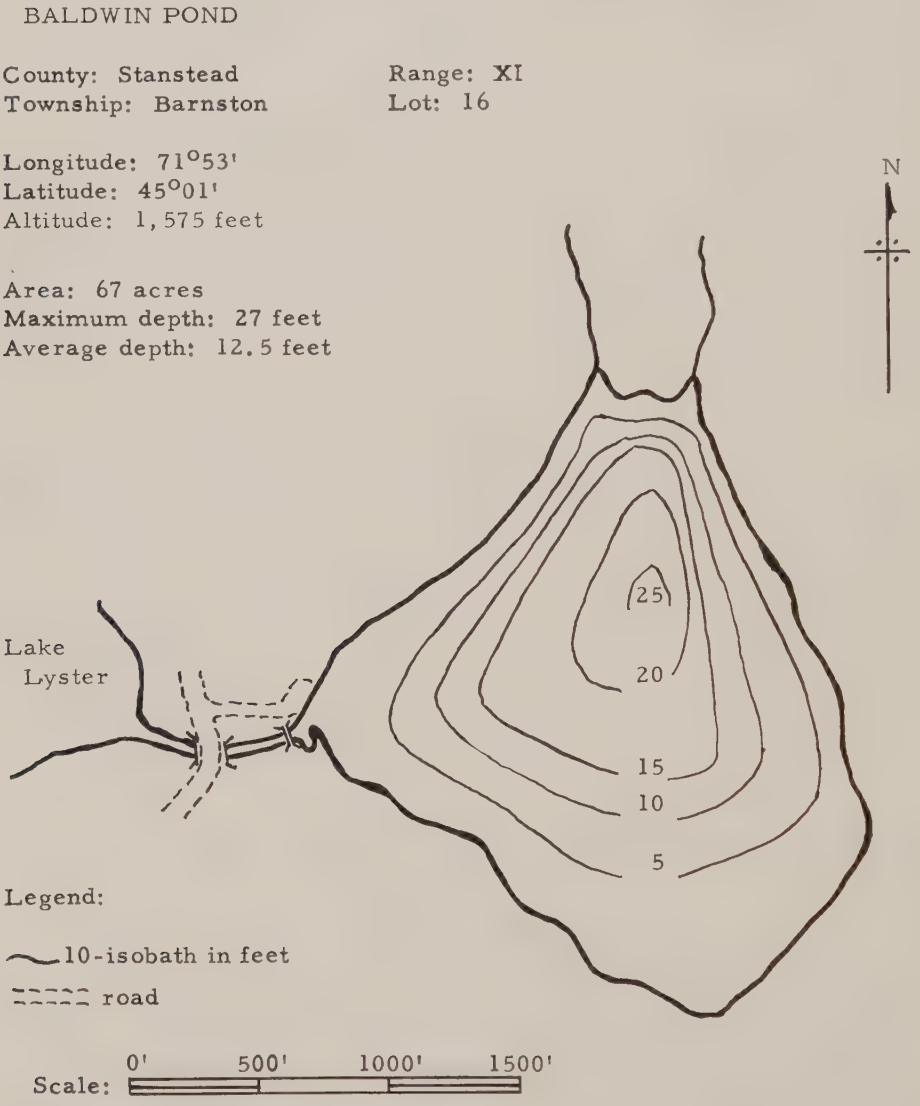

Figure 1.—Description and location of Baldwin Pond.

There was a good season's fishing with 5,407 speckled trout reported. Distribution was as follows:

May 23	2,759 (384 anglers)	June	818
May 24	351	July	515
End May	500	August	253
		September	211
Total for May	3,610		

These figures show a great number of speckled trout taken during the season but tell nothing about the yield per hour per angler. As there are some gaps in the data as to the number of anglers and hours of fishing, particularly for July, we have omitted these doubtful periods from our compilation. In Table I we have a study of fishing yield.

Table I

Yield per angler in Baldwin Pond during 1955 season.

Date	No. of anglers	Trout caught	Fishing hours	Trout per angler	Trout per hour
May 23	374	2,670	1,212	7.18	2.20
May 24	86	351	299	4.08	1.17
End May	193	413	464	2.14	0.89
Total: May	653	3,434	1,975	5.26	1.74
Total: June	366	744	952	2.03	0.78
July 2, 3, 4	36	93	111	2.58	0.83
Total August	144	234	360	1.62	0.65
Total September	104	186	254	1.79	0.73
Total: Season	1,303	4,691	3,652	3.60	1.28

The results of fishing in a lake during the first open season after it has been rehabilitated are highly significant. A yield of 1.28 trout per hour per angler through an entire season is very good fishing.

Comparison is made with results in other Canadian and American lakes in Table II.

In the light of these figures we can place Baldwin Pond in the category of excellent speckled trout fishing water. By continuing to gather angling results during future fishing seasons, biologists will be in a better position to know what trend to follow in future management work to give the anglers of Baldwin Pond continued good returns.

Table II

Comparative yields of various Canadian and U.S. speckled trout lakes.

Trout per hour	Lakes and Places	Creel census duration	Authors
0.2–1.9	Crecy Lake, N.B.	1943–1953	Smith, M. W. 1955
0.3–1.2	Banff National Park (3 lakes), Alta.	1951	Cuerrier and Ward, 1952b
0.2–0.8	Nova Scotia (4 lakes)	1945–1947	Smith, M. W. 1952
0.87	Michigan (trout waters)	1928–1947	Fukano, K. G. 1948
0.8–1.2	Cape Breton Highland National Park (2 lakes)	1951	Cuerrier and Ward, 1952a
0.2–3.3	Jasper National Park (11 lakes), Alta.	1951	Cuerrier and Ward, 1952b
1.1	Charlotte County, N.B. (8 lakes)	1941–1947	Smith, M. W. 1952
1.2	Gull Lake, California	1940–1941	Curtis, B. 1951
1.28	Baldwin Pond, Quebec	1955	Present document
1.7	Castle Lake, Calif.	1947–1949	Curtis, B. 1951
1.4–2.5	Montague Pond, P.E.I.	1943–1953	Smith, M. W. 1954
3.1–4.0	Fundy National Park, N.S. (3 lakes)	1951	Cuerrier and Ward, 1952a

Fishing Methods

On the opening day, May 23, anglers were asked about their method of fishing. As Table III shows, the majority of anglers went in for just one type of fishing. However, a few tried two or even three methods. In these latter cases it was hard to find out just what device captured the fish, so we have refrained from detailing them. Still fishing was the most popular and had excellent results. However, although more trout were taken this way, spinning proved more efficient, although it was less used because of the more expensive equipment needed. On May 23, still fishers caught 2.04 speckled trout per hour while spinners took 2.95 speckled trout. The best spinning device proved to be the Mepps Spinner. We believe some fly fishermen became discouraged and tried another method. These were probably the less expert at the exacting sport of fly fishing, because those ten who adhered to fly fishing achieved the same fishing efficiency as those who confined themselves to the easier method of still fishing. Only twelve fishermen finished the day with empty creels.

Table III

Fishing methods used at Baldwin Pond May 23, 1955.

Fishing method	No. of anglers	Trout taken	Trout per hour
Still fishing (worms)	240	1,667	2.04
Spinning	51	417	2.95
Spinning and still fishing	45	374	
Fly	10	96	2.04
Fly and spinning	3	24	
Still fishing, spinning, fly	4	40	

Growth of Speckled Trout

In addition to registering the fishing results on May 23 and 24, the three different plantings of speckled trout were measured and weighed in order to study their growth in Baldwin Pond. As only legal-length (7 inch) fish were reported, it was necessary to await the opening of the 1955 season to get the results of the fall planting of 1954. However, there were a few clipped-fin specimens reported from the fall planting of 1954 and the spring planting of 1955.

Table IV shows the minimum, average and maximum size per group. A glance at age groups, say yearlings, from the same hatchery but planted at different seasons shows that those planted as fingerlings in the fall and which consequently spent the winter and early spring in Baldwin Pond had better growth than those of the same age which wintered at the hatchery and were planted at the beginning of spring preceding the fishing. True, there are not many of these latter; but it does seem for these two days that the difference is remarkable.

Table IV

Length and weight of speckled trout taken May 23 and 24, 1955 for different plantings.

Group	Age	Date	Number	Length in mm.			Weight in oz.		
				Min.	Ave.	Max.	Min.	Ave.	Max.
Not marked.....	II	May 23	2,673	155	245.5	310	1.00	4.75	9.00
		May 24	317	180	239.7	285	1.75	4.32	7.00
Left pectoral fin off*.....	I	May 23	52	165	206.7	240	1.25	2.88	5.00
		May 24	17	170	204.7	244	1.50	2.73	6.00
Right pectoral fin off**....	I	May 23	4	175	194.5	221	1.75	2.37	3.00
		May 24	4	182	193.0	200	1.75	2.18	2.50

* Planted in fall 1954 as fingerlings.
** Planted in spring 1955 as yearlings.

Speckled trout hatchery-reared a year and planted in Baldwin Pond reached, in length and weight, a year later, the following measurements: the 2,673 speckled trout of the same age measured from 155 and 310 mm. (6 to 12 inches) and weighed from 1 to 9 oz. (28 to 255 grams). Average length was 245.5 mm. (9.7 inches) and average weight 4.75 oz. (135 grams).

For a population of speckled trout of the same age, say two years, it is highly interesting to know at that time of the year, in this case May 23, the trout's conditioning factor and relate this to the conditioning factors of other speckled trout in comparable circumstances. To this end we use the formula set up by Klak (1941), English system:

$$CF = \frac{W \times 100.000}{L^3}$$

where CF stands for coefficient of condition in the English system,

W stands for weight in pounds

L stands for total length in inches

100,000 is a multiplier used to establish the decimal point at the right of two significant figures.

Taking the average length and weights found in Baldwin Pond, we find CF to be 32.5, with minimum 24.9 and maximum 38.1. Table V compares these results with those obtained by Greene (1952) from speckled trout of the same age in Stillwater Pond, Putnam County, New York.

Table V

Conditioning factor of speckled trout in Baldwin and Stillwater Ponds.

Pond	Group	Number	Age	Area (acres)	Maximum depth (feet)	Conditioning factor
Stillwater.....	Hatchery.....	189	II	55	30	ave. C(TL.) 40.3
	Wild.....	149	II	—	—	ave. C(TL.) 31.5
Baldwin.....	Hatchery.....	2,673	II	67	27	ave. C(TL.) 32.5

Table VI distributes the 2,673 speckled trout by length and weight groups, so we can plot a growth curve (Fig. 2). Since it is illegal to take speckled trout less than 7 inches long, it is understandable that the number of captures of shorter fish is not representative of the population. Hence, in plotting the curve for this population we have omitted groups less than 175 mm. in average length.

Total length is related to weight according to the formula:

$$W = cL^n$$

where

W is weight in grams,

L is total length in millimeters,

c and n are constants to be determined, being characteristics of the lake and the fish.

These constants can be calculated according to the following formulae, which are solutions of the initial equation resolved by the method of least squares:

$$Log\ c = \frac{\Sigma Log\ W.\ \Sigma(Log\ L)^2 - \Sigma Log\ L.\ \Sigma(Log\ L.\ Log\ W)}{N.\ \Sigma(Log\ L)^2 - (\Sigma Log\ L)^2}$$

$$\text{and } n = \frac{\Sigma Log\ W - (N.\ Log\ c)}{\Sigma Log\ L}$$

Here N represents the number of length-classes utilized in the calculations.

The length-weight relationship for Baldwin Pond can now be concretely expressed by:

$$W = 2.995 \times 10^{-5}\ L^{2.781}$$

Table VI

Length-weight relationship of speckled trout in Baldwin Pond.

Total length in mm. by classes of 10 mm.	Number of fish	Weight in grams
151–160	1	28.35
161–170	2	31.89
171–180	4	53.15
181–190	11	55.08
191–200	21	68.32
201–210	38	87.82
211–220	133	94.34
221–230	288	109.45
231–240	554	119.06
241–250	644	129.72
251–260	505	148.40
261–270	271	165.36
271–280	132	184.15
281–290	40	200.57
291–300	24	218.51
301–310	5	241.67
	2,673	

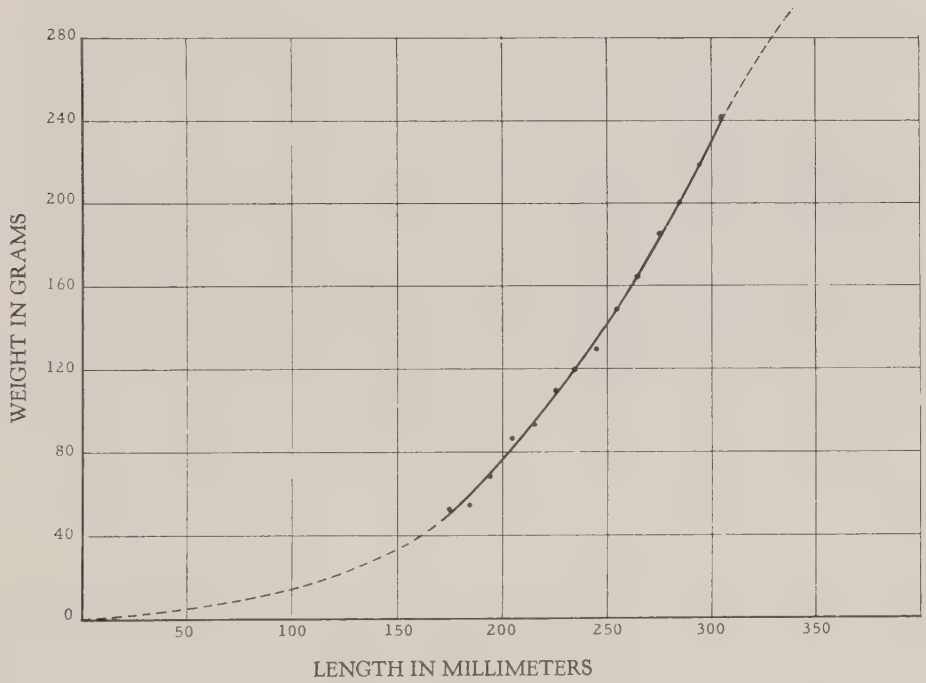

Figure 2.—Length-weight relationship of speckled trout two years old in Baldwin Pond. (Points are based on lengths and weights, Table VI.)

Operation and installation for weighing and measuring fish for creel census at Baldwin Pond in spring of 1956. Richard L. Séguin, author, (left), his brother, also a biologist, Louis-Roch Séguin (right) and a local fisherman.

Summary

Baldwin Pond appears well managed to date. After the poisoning of the unwanted species of fish during fall 1953, the lake was ready to receive the speckled trout plantings of 1954 and 1955. The 1955 fishing season gave the first pertinent data necessary for the management of the lake. Successive creel censuses were the best tool to check management.

The opening day, May 23, was very successful; 384 anglers caught 2,759 speckled trout. To prevent rapid depletion of the fish from the lake, in co-operation with the

organized anglers, a limit was set of ten fish per angler per day. The 5,407 speckled trout caught and reported from May 23 to the end of September prove that the plantings of hatchery stock gave good results.

The yield of 1.28 trout per hour per angler for all the season proves the value of the lake as a speckled trout producer. The anglers made an outstanding contribution during this study of the lake.

Still fishing, the preferred method of the majority, proved very efficacious. On May 23, 2.04 trout per hour were taken by this method. Spinning and fly fishing which were less in vogue were also effective. These more active methods need a little more equipment and are not, perhaps, for the inexperienced angler. To make a complete analysis of the fishing methods it would be necessary to study the baits and lures used by anglers.

As Baldwin Pond seemed overpopulated at the opening of the season, it is understandable that the conditioning factor may be a little low. It did not prove practicable to learn the factor at the end of the fishing season, but it is a reasonable hypothesis, which later studies may confirm, that the conditioning factor improves in Baldwin Pond as overpopulation is reduced by fishing. By continuing the census year after year, it would be easier to approach the answer. Other data will help to compare growth curve. The constant $n = 2.781$ characteristic of the fish is a little lower than the optimum $n = 3$, but it is still very good.

Acknowledgments

This study has been carried out as part of the freshwater management programme of the Quebec Biological Bureau, directed by Dr. Gustave Prévost. This work has been greatly aided by Louis-Roch Séguin, biologist and director of the Eastern Townships Fish Hatchery. It is a pleasure to acknowledge the co-operation of all anglers of Baldwin Pond during the creel census. Thanks are due also to Paul Bouchard, Larry Wilson and other associates in the Quebec Biological Bureau for helpful suggestions in the preparation of this manuscript.

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Lea's Hydrostatic Tag on Brook Trout and Atlantic Salmon Smolts

by

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Einar Lea first demonstrated the hydrostatic tag at a meeting of the International Council for the Exploration of the Sea in 1948. Since that time this tag has been used by a number of investigators on several species of fish. Dannevig (1953) obtained better returns with hydrostatic than either disk or strap tags in his studies of Norwegian cod. However, of more interest to us is the use of the hydrostatic tag on salmonoids. Went (1951, 1953) and Went and Vickers (1953) employed Lea's tag to advantage in tracing the movements of adult Atlantic salmon along the Irish coasts. Vibert (1953) tagged salmon smolts in southern France. A few of these smolts were later recaptured by mackerel fishermen well to sea in the Atlantic. Jensen (1955) recovered as high as 44.8 per cent of rainbow trout tagged and liberated in Roskild Fjord, Denmark.

In 1950 the hydrostatic tag was used on brook trout and smolts of the Atlantic salmon at Ellerslie Brook, Prince Edward Island. Since jaw tags had been and were currently being employed on brook trout at Ellerslie, a comparison of results from two types of tagging was possible. This article presents the results.

Lea's Hydrostatic Tag

The hydrostatic tag is illustrated in Figure 1. It has been previously described (Anon., 1953; Rounsefeld and Everhart, 1953; Went, 1951). Briefly, the tag consists of a small celluloid cylinder, plugged at both ends, and containing written instructions to the finder. It is attached by a bridle of stainless steel to a wire pin which pierces the flesh of the fish, usually just anterior to the dorsal fin (Fig. 2). Nylon line has been used for attachment in some instances (Collyer, 1954; Dannevig, 1953; Jensen, 1955). The specific gravity of Lea's tag is somewhat less than that of water.

The tags used at Ellerslie Brook were obtained from Mr. Lea. They were three centimetres long and four millimetres in diameter and coloured yellow with blue-tipped ends. Printed on the tag were the words "Canada", "Reward", and "cut ends, message inside", and a serial number.

Tagging

Tagging was done in connection with a study of the movements and populations in Ellerslie Brook of the brook trout primarily and the Atlantic salmon secondarily (Smith, 1951). Fish are captured in a two-way fish trap (trap A) as they move between

salt water and Ellerslie Brook. A second similar trap (trap B), situated 650 yards upstream, captures fish as they move between the lower and upper sections of the brook. The traps have been described previously and their efficiency evaluated (Smith and Saunders, 1956).

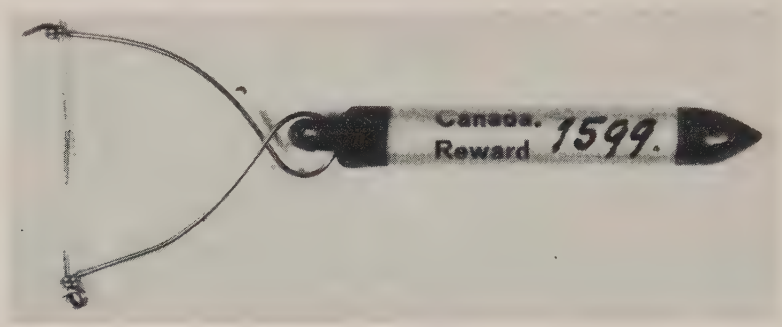

Figure 1.—Lea's hydrostatic tag.

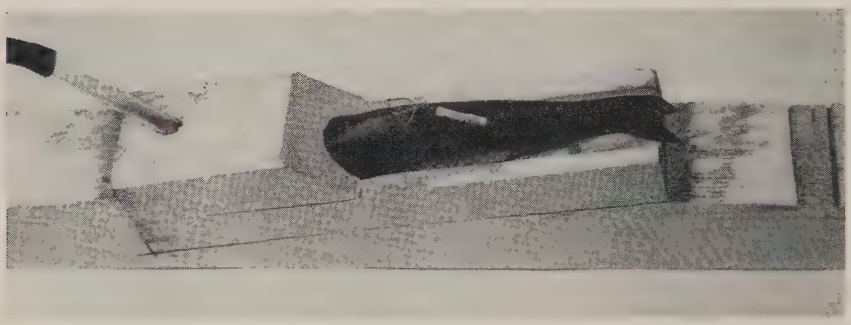

Figure 2.—Wooden "boot" in which trout were held during tagging.

Fish were held in a wooden "boot" while the hydrostatic tag was attached (Fig. 2). A continuous flow of water was supplied through a hole at the head of the "boot". The forward end of the "boot" was tilted downward to insure that the head of the fish was entirely submerged. Three "boots" with holes of different diameters were used. It was necessary to have the hole sufficiently large so as not to interfere with movements of the opercula in respiration, yet small enough to retain the fish well. The fish remained quiet during the entire tagging operation.

The following operations were involved in the tagging. The flesh of the fish, just anterior to the dorsal fin, was pierced with a number 18 hypodermic needle. A right-angle bend was made at one end of the pin. The straight end of the pin was threaded through one loop of the bridle and then through the hypodermic needle. The needle was withdrawn, the pin cut to the desired length and the other loop of the bridle slipped over the pin. Finally the straight end of the pin was bent, using two needle-nosed pliers, one to hold the pin rigidly, the other to bend it.

From June 14 to July 4, 1950, hydrostatic tags were placed on 100 brook trout as they moved into Ellerslie Brook through trap A. These trout had an average fork length of 18.4 $\pm$ 0.62 cm. Similarly, in the period November 16 to 20, 1950, 77 trout

were tagged as they went downstream through trap B, and 23 others when they were taken going to salt water through trap A. The mean fork length of these two groups of trout were 16.0 ± 1.60 and 16.3 ± 2.87 cm. respectively.

During April and May, 1951, hydrostatic tags were also applied to 493 salmon smolts as they ran to sea through trap A. These salmon had an average fork length of 13.6 ± 0.57 cm.

From June 1 to July 27, 1950, 152 trout were jaw-tagged when they moved into the brook through trap A. During the month of November, 1950, jaw tags were also applied to 312 trout as they ran downstream through trap B and 261 as they went to salt water through trap A. This tagging was a continuation of a programme already under way at Ellerslie Brook whereby all trout moving through the traps, up- or downstream, were tagged. The jaw tag was of the strap variety, applied in a circular form around the mandible of the trout (Smith, 1957).

Recapture of Tagged Trout

Records of recapture of tagged trout were obtained in a number of ways: (1) from the traps, (2) by an annual creel census maintained on the brook and estuary, (3) during population studies in the brook, and (4) by capture in commercial smelt nets in the estuary.

Table I

Recaptures of trout bearing hydrostatic tags.

Manner of recapture	Number recaptured and time at large		
	<1 week	2-4 weeks	<4 weeks
I—Of 100 trout tagged in A trap going upstream			
Angled	9	4	2
In traps	1	0	1
During population studies	0	1	1
In gill-nets	0	0	1
II—Of 77 trout tagged in B trap going downstream			
Angled	0	0	4
In traps	24	4	7
In gill-nets	6	0	0
III—Of 23 trout tagged in A trap going to salt water			
In traps	0	2	1
In gill-nets	2	0	0

Table II

Comparison of number of recaptures of trout bearing hydrostatic and jaw tags

Place tagged	Number tagged	Recaptures		Number of recaptures after 100 days at large
		Number	Percentage	
I—With hydrostatic tags				
A trap up	100	20	20	1
B trap down	77	45	58	5
A trap down	23	5	22	1
Totals	200	70	35	7
II—With jaw tags				
A trap up	152	93	61	36
B trap down	312	214	69	111
A trap down	261	179	69	94
Totals	725	486	67	241

Hydrostatic tags.

Data on the recapture of trout bearing hydrostatic tags are summarized in Tables I and II. Seven tagged trout were recaptured twice. The first time was in trap A as they ran to salt water. However, only the final recapture is recorded in the tables.

There were 20 recaptures from the 100 trout tagged as they entered the brook. The majority (13) of these recaptures was made by anglers within a month of the tagging dates. The longest period that any of this group of trout was at liberty between tagging and recapture was 150 days.

Forty-five (58 per cent) of the 77 trout tagged in trap B as they moved downstream were recaptured. These trout were tagged in November when there is a general movement from the brook to salt water. Accordingly, it is not surprising that the greater number of recoveries were made at the mouth of the stream in trap A within a few days. Six individuals were subsequently taken in gill-nets in the estuary within a period of a week. Five from this group of 77 trout were at liberty 132 to 151 days between tagging and last recapture.

Five recaptures were made from the 23 trout tagged in trap A when running to salt water. Two individuals were captured within a week in gill-nets. The other three were taken in trap A as they re-entered the brook, one after being in salt water for 220 days.

In summary, 35 per cent of the trout bearing hydrostatic tags were recaptured. However, the majority of these trout were at liberty for the short period of less than one month. Recovery of tagged trout after having run to salt water was poor. Out of 200 trout with hydrostatic tags, only seven upon recapture had been at large for more than 100 days.

Jaw tags.

As shown in Table II, 67 per cent of the trout that were jaw-tagged as they moved up- and downstream through the traps were recaptured. There was little difference in the percentage recovery between those tagged going upstream and those that were running downstream and into salt water. In contrast to the returns with hydrostatic tags, a large proportion (50 per cent) of the jaw-tagged trout were at liberty over 100 days before recapture.

Recapture of Tagged Salmon

There are no records that any of the 497 smolts bearing hydrostatic tags were recaptured. Twenty adult salmon entered Ellerslie Brook during the fall of 1953 and 17 in 1954. None of these fish showed any evidence of having been tagged. It is possible that tags could have been shed without leaving recognizable scars. However, careful examination of each salmon failed to reveal any. No capture of salmon with hydrostatic tags has been reported from the commercial salmon fisheries of the Gulf of St. Lawrence area.

Two hydrostatic tags that had become free from the fish were found. One was picked up on the shore of Lennox Island in Malpeque Bay at a point about two miles from the mouth of Ellerslie Brook. The other was found on the beach at Percé, Quebec, a distance (shortest) of about 150 miles from Ellerslie. Since the tag is hydrostatic it would act in the manner of a drift bottle after being freed from the fish.

Summary

It was observed that the bridle of the hydrostatic tag became fouled with aquatic vegetation, especially filamentous algae, in Ellerslie Brook and estuary. In the brook, the trout, including tagged individuals, sought hiding places when disturbed. In so doing it seems probable that snagging of the bridle would frequently occur. It was further observed that the hydrostatic tag and its bridle tended to ride to one or the other side of the fish. As a result, the flesh of the fish was abraded by the end of the bridle where twisted around the pin and by the sharp free end of the pin itself. These conditions would militate against the survival of the fish and the retention of the tag.

The brightly-coloured hydrostatic tags were surprisingly conspicuous in the clear water of Ellerslie Brook. The bright colours were intentionally used to aid in recovery of the tags, yet their conspicuousness might attract undesirable attention. In this regard it was noted that trout struck at the hydrostatic tags carried by other individuals.

The fortuitous recovery of two unattached hydrostatic tags that had been placed on salmon smolts has been noted. Five additional unattached tags were found in Ellerslie Brook. These had been put on trout. However, the loss of these tags did not necessarily indicate death of the fish as shown by the capture of seven previously tagged trout with scars at the point of attachment of the tags. It is pertinent to note that jaw tags were shed by trout without apparent injury to the fish. Of 1,625 trout that had been jaw-tagged and subsequently recaptured in trap A during 1950, 70 (4.3 per cent) had lost the tag. (In applying both the hydrostatic and jaw tags the adipose fins were removed, which aided in spotting the previously tagged fish.)

Although tried on only a few salmon smolts, it was found that the tendency of the hydrostatic tag and its bridle to slip sideways was largely prevented by placing two small celluloid disks on the pin or either side of the fish and inside the attachment of the bridle. The disks added some encumbrance to the tag. Attachment with nylon line may have lessened the difficulty. Jensen (1955) experienced more recaptures of rainbow trout when nylon was used to attach hydrostatic tags. On the other hand, Collyer (1954) found that attachment with nylon gave no better results than when wire was employed in tagging the yellowtail (*Seriola dorsalis*).

The hydrostatic proved inferior to the jaw tag when used on trout at Ellerslie Brook. Fouling and snagging of the tag, more to be experienced in the confined quarters of Ellerslie Brook and estuary than in open waters, were important factors conditioning the results.

Acknowledgment

The assistance of J. W. Saunders, C. R. Hayes and Cyril Williams is gratefully acknowledged. This paper is published with permission of The Fisheries Research Board of Canada.

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EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1957.